OPIC
OFFICE DE LA PROPRIÉTÉ INTELLECTUELLE DU CANADA

CIPO
CANADIAN INTELLECTUAL PROPERTY OFFICE

Ottawa Hull K1A 0C9

(21) (A1) 2,127,339
(22) 1994/07/04
(43) 1996/01/05

(51) INTL.CL. 5 B24B-019/00

(19) (CA) **APPLICATION FOR CANADIAN PATENT** (12)

(54) Material Surface Modification

(72) MacKelvie, Winston R. - Canada ;

(71) Same as inventor

(57) 23 Claims

Notice: This application is as filed and may therefore contain an incomplete specification.

2127339

ABSTRACT

A surface treatment for readily machinable materials involves forming a series of spaced non-overlapping planing cuts in a generally planar surface of the material so as to leave non-detached curved and at least partially retroverted cuttings projecting from the surface. The surface treatment permits various forms of improved interaction with other materials whether through adhesive or other bonding to such materials or heat exchange or other surface interactions with fluids. Bonding may be by adhesives and/or mechanical interaction with similarly prepared surfaces, or by causing another material to flow around and into the cuttings and the cuts from which they are formed. Various mechanisms for performing the surface treatment are described.

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

This invention relates to the surface preparation of solid materials to improve their interaction with other materials. Such interaction may include adhesive and/or mechanical bonding, heat exchange, catalysis or frictional engagement.

REVIEW OF THE ART

It has long been known to roughen, abrade, mechanically indent or otherwise modify or mechanically deform the surface of materials to improve their interaction with other materials in a wide range of applications. For example such preparation usually improves the bonding of the prepared material to other materials such as adhesives used to adhere the surface to a surface of another material, or to materials directly bonded to the surface of the first material, as by casting, fusion bonding, and coating, plating or other forms of deposition. Such preparation may also be used to improve contact between the surface and a fluid, as for heat exchange purposes, or to raise its coefficient of frictional engagement with other surfaces, for example to reduce slippage. Such surface preparation techniques operate by increasing the surface area of the material, providing contact surfaces in many different planes rather than a single plane so as to provide improved keying and ensuring that a fresh surface of the material is exposed for interaction.

Most surface preparation techniques involve only a surface plane of the material having very limited thickness, and while such techniques are often very useful and effective, they necessarily involve a correspondingly thin layer of the material with which interaction can take place. Such techniques are not usually very effective in providing improved interaction with fluids, since the irregularities in the surface occur largely in a more or less static boundary layer of the fluid. While techniques involving extensive penetration and deformation of the material have been proposed or utilized, they involve a correspondingly substantial thickness of the material being treated, which entails that the material must be in a layer of much greater thickness if substantial weakening of the material is to be avoided. This difficulty is well illustrated by the arrangement shown in U.S. Patent No. 3,746,086 (Pasternak) in which the walls of heat exchanger tubes are provided with increased surface area by a series of deep diagonal cuts forming fir-cone like vanes on the tube. To accommodate these cuts, the material of the tubes is formed with massive external ribs to provide material for the vanes without prejudicing the integrity of the tube walls. Likewise, the bonding technique of U.S. Patent No. 4,349,954, in which the surface of a material is formed into a forest of cones, is clearly feasible only with workpieces of much greater thickness than the depth of the cones formed on the workpiece surface.

In general, none of the techniques considered above provide, in bonding applications, for any form of positive interlocking or interengagement between the material whose surface is treated and a material with which the treated surface interacts.

Another well known form of surface treatment of material is planing, in which a planing tool is utilized to plane shavings from the surface of the material so as to

flatten it or reduce it to a desired contour. One known form of planing tool is the "speed file", as exemplified by Canadian Patent No. 927,081, which has multiple small spaced apart planing blades which conjointly cut a number of spaced shavings from the surface of a material being planed. The multiple blades, and the application of multiple strokes, result in overlapping of the planing cuts producing an overall planing of the material and providing a smooth surface.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a technique for preparation of a surface of a material to provide it with improved interaction and positive interengagement with an interacting material, within a zone whose thickness can be very large compared to the extent of surface penetration of the material required by the technique. The technique is applicable to readily machinable material, which is defined in the context of the present invention as a material from which a cutting blade may plane or gouge a continuous cutting or shaving which can be smoothly curled out of the cutting plane without fracture. It is generally associated with substantial ductility of the material. It will be understood that some materials which are not readily machinable at ambient temperatures may be rendered ductile by the application of suitably elevated temperatures.

The invention in one aspect provides a method of modifying a workpiece of presenting freely machinable material at a generally planar surface thereof, comprising planing without detachment a plurality of curved, elongated and at least partially retroverted cuttings from spaced, non-overlapping, elongated troughs of approximately constant distribution over said surface, the cuttings remaining continuous with the planar surface at one end of each trough, using at least one tool providing a planing

action with a stroke which is small compared with the dimensions of the surface to be treated, whereby to provide the workpiece with a modified surface of increased surface area, part of which increased area is provided by surfaces of the cuttings which face towards and are spaced away from a remainder of the workpiece.

Preferably the distal ends of the cuttings are retroverted through more than 180° so as to present a series of hooks or loops. The invention also extends to material having a surface so treated.

It will be appreciated that penetration of the troughs cut into the surface of the material will be limited by the planing action of the tool, but the length of the cuttings is limited only by the requirement that the zones from which they are planed do not overlap, while their protuberance from the surface will depend on their curvature, which is a function of the tool design, but will normally be very much greater than the planing depth. The retroversion of the cuttings, as well as continuity of the roots of the cuttings with the surface, provide zones in which the modified surface can positively interengage with another material.

The invention further extends to apparatus for implementing the method and forming the modified workpieces of the invention. The apparatus must perform limited planing strokes distributed over a workpiece surface to be treated, and provide for disengagement of the cutting edges from the workpiece at the end of the planing strokes so as not to separate the cuttings formed from the workpiece. In general terms the apparatus comprises at least one chisel member presenting a cutting edge at a planing angle to said surface, structure providing a gauging surface set back from said cutting edge and controlling depth of penetration of the cutting edge into the workpiece during planing

movement of the cutting of each chisel member relative to the workpiece, structure providing a guide surface directing a cutting planed from the surface of the workpiece by the chisel member into a retroverting curve, mechanism operable to repeatedly relatively displace each chisel member and the workpiece through a predetermined planing stroke whereby to plane a non-detached cutting of predetermined length from a trough in the surface, and operable to withdraw the chisel member from planing engagement with the workpiece, and means for permitting movement of the workpiece relative to the chisel member so that a following planing stroke may be performed on a further zone of the surface spaced from the first zone.

Actual implementation of such apparatus may take various forms as described further below.

SHORT DESCRIPTION OF THE DRAWINGS

In the drawings:

Figure 1 illustrates a fragment of a workpiece showing a single cutting planed from a trough in a surface of the workpiece;

Figure 2 illustrates a workpiece from which have been planed a plurality of cuttings similar to that of Figure 1;

Figures 3, 4 and 5 are fragmentary views similar to Figure 1, showing progressive stages in the formation of a cutting;

Figure 6 is a further fragmentary view showing how cuttings may be pressed back into their associated trough to trap fibres;

Figure 7 is a cross-sectional view showing how two workpieces may be pressed together to interlock cuttings formed on opposed surfaces of the two workpieces;

Figure 8 illustrates a type of interengagement possible when the cuttings are longer and thinner;

Figure 9 illustrates basic features of a tool for

carrying out surface preparation in accordance with the invention;

Figure 10 shows the tool of Figure 9 at a later stage of engagement with a workpiece;

Figure 11 diagrammatically illustrates elements of a first form of apparatus for surface treating workpieces;

Figure 12 illustrates a different phase of operation of the apparatus of Figure 11;

Figure 13 illustrates a means for controlling depth of penetration of planing blades in the apparatus of Figure 11;

Figure 14 is an edge elevation of a workpiece treated with the apparatus of Figure 11, and bonded to a further layer of material;

Figure 15 shows a blade used in a modification of the apparatus of Figure 11;

Figure 16 shows an assembly of two blades as shown in Figure 15, but arranged to cut in opposite directions;

Figure 17 illustrates the assembly of Figure 16 in cutting engagement with a workpiece, illustrating the cutting forces applied thereto;

Figures 18, 19 and 20 are plan and end and side elevational views showing means for registering multiple blades and reciprocating them to perform a planing stroke;

Figure 21 shows in elevation a further embodiment of apparatus for surface preparation of workpieces;

Figure 22 is a detail on an enlarged scale of the apparatus shown in Figure 21;

Figure 23 is a plan view of the apparatus of Figure 21;

Figure 24 is an isometric diagrammatic view of a further embodiment of apparatus;

Figures 25 and 26 show sets of blades used in yet a further embodiment;

Figure 27 is a plan view of the blades; and

Figures 28 and 29 are enlarged views of a single blade at different stages of its stroke.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Figures 1 and 2, a surface prepared in accordance with the invention presents a plurality of spaced, curved tongues 16 formed by cuttings planed out of the surface 12 of the material 10 (which must obviously be sufficiently freely machinable, at least at its surface, for this to be possible). By freely machinable in this context is meant that it is possible to plane from a surface layer of the material and deflect away from the surface a continuous "chip" or coherent curved cutting of the material. The term "cutting" is preferred in the present context rather than "chip" or "shaving" or other terminology used in the machining art, to avoid any implication that the cutting is detached from the surface, or has a particular cross-section, or is formed from the surface by a mechanism other than planing. Some materials, such as certain plastics, may not be freely machinable at ambient temperatures but become so when the workpiece and/or the cutting tool is at an appropriately elevated temperature, and such materials so heated during surface preparation are within the scope of the invention. Materials such as ductile metals and synthetic plastics are examples of materials suitable for application of the invention. It should also be appreciated that it is only the characteristics of the material presented in a surface layer of the workpiece which are significant in relation to the invention.

The term "planing" is utilized to describe the action utilized in preparing surfaces in accordance with the invention, in which a cutting tool is driven into the surface of a workpiece to a controlled depth and thus advanced in a direction generally parallel to the surface of the workpiece to plane or gouge from it a cutting which is deflected away from the surface but remaining attached to the workpiece adjacent the cutting edge. This leaves a trough in the workpiece which is of substantial uniform

cross-section except for an initial portion where the tool enters the workpiece material. Unlike in normal planing or shaping, the tool is not advanced to a point at which the cutting tool severs the cutting from the surface: instead, the strokes of the cutting tool are short enough that they affect non-overlapping portions of the workpiece surface, and are short compared to the dimensions of the surface to be treated, and at the end of a stroke, the relative movement of the tool and the workpiece is reversed to permit the tool to disengage from the workpiece in a manner which avoids detaching the cutting. This is in contrast to regular planing and shaping processes, in which such disengagement is to be avoided, and in contrast to broaching procedures, in which overlapping cuts of progressively increasing depth are required.

It will be noted by reference to Figure 2 and the enlarged fragmentary view in Figure 1 that the tongues 16 are planed or gouged out of the surface 12 from a trough 14 which initially increases in depth as the forming tool 24 (see figures 9 and 10) penetrates the surface to a depth 5 during translational movement as shown by the arrows and then continues at a substantially constant depth as the translational movement of a cutting edge 4 continues, the resulting cutting being deflected in a curved path up the surface 2 so as to form a tongue 16. As shown in Figures 3, 4 and 5, the degree of retroversion of the tongue increases as the length of the cutting stroke increases, and may be selected to suit the application. Tongues 16a and 16b directed in opposite directions may be provided.

Figure 6 illustrates how fibres 18 from a sheet of fibrous material, which may form reinforcement for a layer of resin, may be physically bonded to the surface of the workpiece by applying pressure to the workpiece to flatten the tongues 16 partially back into the troughs 14 and thus trap the fibres 18: the tongues are thus keyed both in the

resin and its reinforcement, providing a superior bond.

Figure 7 illustrates how tongues formed on two similarly prepared workpieces may be interengaged and the workpieces then pressed together to flatten and further interengage the tongues, thus physically locking the layers together and complementing the action of a layer of adhesive 19. Figure 8 shows a similar technique, except that the tongues are much longer and thinner, forming curly fibres 22. The fibres from the two workpieces intertwine and interlock somewhat in the manner characteristic of hooked pile fabrics such as those sold under the trademark VELCRO. The fibres 22 can of course form reinforcement for a resin layer 23, as well as bonding it to the workpieces.

A prepared workpiece 10 may also be bonded to a further layer 25 of material (see Figure 14) by causing the material to surround the tongues 16 and fill the troughs 14. This may be achieved in various ways, for example, a layer of setting resin, metal or other material may be cast, plated or otherwise deposited or coated onto the workpiece 10, and caused to cure or set, or material may be deposited in powder form and subsequently fused, or a layer of fusible material may be pressed onto a heated workpiece 10 to cause local fusion of the material so that it flows around the tongues 16 and into the cuts 14. In one application, the workpiece may form a battery plate, and active electrode material may be bonded to the surface.

It will be noted that an effect of the retroversion of the cuttings that produce the tongues 16 is that, as well as increasing the surface area of the workpiece, the cuttings present surfaces that face back towards the workpiece and thus provide positive engagement with a material with which the treated surface interacts.

It will also be noted that the protrusion of the

tongues 16 formed by the cuttings is large compared with the depth of the troughs 14. This has the dual benefits that substantial protuberances from the surface may be produced without involving more than a surface layer of the workpiece, and that the protuberances can be extensive enough to penetrate through a boundary layer of a material with which the treated workpiece interacts. This is valuable not only in increasing the strength of bonds of various types already considered, but also when the interacting material is a moving fluid, whether a gas or a liquid, for heat exchange or catalysis purposes, since the tongues will extend through a relatively static boundary layer to interact with the moving fluid, and the retroverted tongues will induce turbulence in the fluid adjacent the treated surface. As well as the mechanical treatment already considered, this treatment may include the application of a layer 15 (see Figure 1) of catalyst to the tongues. The tongues may also be either left as is, or compressed, in order to provide increased frictional interaction with solid bodies, i.e. a non-slip surface.

A simple planing tool as shown in Figures 9 and 10 may be utilized to apply the surface treatment discussed above in that the block 24 provides a hand grip by means of which the tool may be moved in the direction of the arrow to apply a planing stroke and withdrawn in the opposite direction to disengage the tool from the cutting. The bottom surface of the block 24 provides a gauging surface which limits the penetration of the blade 4 into the surface, and the surface 2 curves and retroverts the cutting. The hand grip permits the tool to be moved to different parts of the surface to provide a series of non-overlapping cuts, which may be reversed in direction to provide cuts in the opposite direction.

In most commercial applications, a less labour intensive technique is required. The apparatus shown in

Figures 11-13 may be utilized to prepare workpieces 10 as shown in Figure 14. The apparatus comprises a set alternating complementary cutting blades 31 and 32, each with multiple cutting edges 4, the edges being directed in opposite directions on the tools 31 and 32 respectively. Each edge 4 is associated with a surface 2 for curling the cutting 16 it produces, and each blade is formed with a bell-curved notch 8 in its upper surface, slightly offset from its centre. The blades 31 and 32 may be identical, their designation depending upon the direction in which their edges face. Although the blades resemble broaching tools, they differ in that there is no progression in the depth of cut of the multiple cutting edges 4. The set of blades 31 and 32 is subjected to bias pressure on its ends to tending to force the blades into alignment as shown in Figure 1. A cylindrical actuator 3 is reciprocated between the position shown in Figure 11 and the position shown in Figure 12, forcing the blades downwardly and outwardly as shown by arrows 6 and 7 to provide a plurality of planing cuts in a workpiece as shown in Figure 14 (ignoring the layer 25). Plates 9 (see Figure 13) on the outsides of the set of blades provide gauging surfaces 11 which limit the penetration 5 of the cutting edges 4 into the workpiece.

A modified cutting tool 31 is shown in Figure 5 in which the gauging surfaces 11 are incorporated into the tool. The action of this modified tool in relation to a workpiece 10 is illustrated in Figures 6 and 7, while further details of means to bias the tools and actuate the tools are to be seen in the apparatus illustrated in Figures 18-20. The tools 31 and 32 are vertically aligned by pins 18 passing through horizontal slots 17 in the ends of the tools, which may be spaced if desired by shims 13. The bias on the tools is provided by tension springs 19 acting on extensions 18a of the pins 18 so as to cause the latter to act on inner ends of the slots 17. The actuator 3 extends between plates 40 supporting an anvil 41 which

may be struck to force the pin 3 into the bell shaped recesses 8 and thus actuate the tools to provide a series of cuts in spaced non-overlapping zones over a surface of the workpiece 10. Means (for example similar to the ports 64 and 66 in Figure 21) may be provided to advance a continuous workpiece laterally or longitudinally relative to the apparatus between each blow on the anvil 40 so that successive portions of the surface may be treated.

Referring now to Figures 21-23, apparatus suitable for processing of the surface of a continuous sheet is illustrated. Cutting blades 4 and associated retroverting surfaces are formed on links 50 of a series of parallel chains 52 supported on sprocket sets or rollers 54, 56, 58, 60 and 62. Material whose surface is to be treated is advanced across a support 64 beneath the sprocket set 60 by rollers 66 which are geared to the sprocket 62 such that the material 10 is advanced by them at a rate substantially greater than the rate at which the chain 52 pass beneath the sprocket set 60. As each tooth 4 passes beneath the sprocket set 60, it enters the surface of the workpiece 10 to an extent gauged by the position of the support 64 relative to the sprocket set 60. Since the tooth 4 faces away from the direction of advance of the chain and the workpiece, and the workpiece is travelling faster than the chain, the tooth performs a planing stroke relative to the workpiece so as to penetrate the latter, cut a cutting from it and then withdraw from the cut as best understood from Figure 2. Although the cutting strokes of the teeth are not strictly linear, the trough produced will still be of sufficiently uniform depth to meet the requirements of the invention provided that the diameter of the sprocket set 60 is very large compared to the depth of cut. In a variation of this embodiment shown in Figure 24, the teeth 4 are formed directly on a set of disks 70 replacing the combination of the sprocket set 60 and the chains 52. In a further variation the chains 52, or the periphery of the

set of disks in the modified embodiment of Figure 24, are driven so as to advance faster than the workpiece, but are braked to a standstill for a predetermined period each time a tooth engages the workpiece so as to cut a trough of predetermined length. In the embodiment of Figures 21-23, the braking may be applied to sprocket set 62.

In the embodiment of Figure 24, similar reference numerals are utilized where applicable, but the chains 52 and associated sprockets are replaced by the disks 70. In the example shown, these are mounted on a square section shaft 72, inserted through square central apertures 78 in the disks, the shaft being advanced intermittently in the direction of the arrow 74 at a rate greater than the workpiece is moved in the direction 76 so as to bring a tooth 4 into engagement with the workpiece, at which point the shaft is halted so that the workpiece is moved past the blade as shown and cuts a cutting 16 from a trough 14. After a period sufficient for a trough of the desired length to be cut, the shaft is indexed to engage the next blade with the workpiece. Either the back of the teeth are sharpened to aid penetration, or sufficient resilience is provided in the mechanism to allow a tooth to be advanced to the starting point of a cut.

A further embodiment of apparatus is shown in Figures 25-29. This embodiment utilizes rows of rotatable cutter members 90 of generally volute form, the cutter members in each row being mounted on a carrier 88 in a common plane on pivots 92 with their axes horizontally spaced. Typically the axes of members in adjacent parallel rows will be offset, as shown in plan in Figure 27. Members in a row have crank pins 94 connected by a coupling rod 96, the positioning of the crank pins on the members in different rows being such (see Figures 25 and 26) that motion of the connecting rods in the same direction B will rotate the sets members in opposite directions A to cause cutting

blades 4 on the members to plane cuttings from a workpiece 10 (see Figure 28). While movement of the rods in the opposite direction will withdraw the blades 4 from the workpiece (see Figure 29). The volute form of the periphery cutter members forms a gauging function controlling the depth of cut. The workpiece 10 to be surface treated is indexed by a feed mechanism (not shown) in the direction C (see Figure 27) between each reciprocation of the coupling rods 96 which may be driven from a crankshaft (not shown) by connecting rods (not shown).

It will be appreciated that the examples of applications and manufacturing apparatus outlined above are exemplary only and modifications and variations thereof are within the scope of the invention as defined by the appended claims.

I CLAIM:

1. A method of modifying a workpiece presenting freely machinable material at a generally planar surface thereof comprising planing without detachment a plurality of curved, elongated and at least partially retroverted cuttings from spaced, non-overlapping, elongated troughs of approximately constant depth distributed over said surface, the cuttings remaining continuous with the planar surface at one end of each trough, using at least one tool providing a planing action with a stroke which is small compared with the dimensions of the surface to be treated, whereby to provide the workpiece with a modified surface of increased surface area, part of which increased area is provided by surfaces of the cuttings which face towards and are spaced away from a remainder of the workpiece.

2. A method according to Claim 1, wherein the distal ends of the cuttings are retroverted by cutting through more than 180° with respect to the planar surface at the one ends of the zones.

3. A method of establishing contact between a workpiece having freely machinable material at a generally planar surface thereof and an at least temporarily fluent material, comprising modifying said surface of the machinable material according to the method of Claim 1, and flowing the fluent material into contact with the extended surface area of said surface.

4. A method according to Claim 3, wherein the fluent material is a fluid in heat exchange relationship with the extended surface area.

5. A method according to Claim 3, wherein the fluent material is a mixture of reagents whose reaction is

catalyzed by the modified surface.

6. A method according to Claim 5, wherein the modified surface is surface treated after formulation and prior to contact with the mixture to provide it with catalytic properties.

7. A method according to Claim 3, in which the fluent material is a liquid settable to a solid.

8. A method according to Claim 7, wherein the settable liquid is a layer of adhesive, and including the step of bonding a second workpiece to the adhesive layer.

9. A method according to Claim 8, wherein the second workpiece has a surface modified similarly to that of the first workpiece.

10. A method according to Claim 9, wherein the cuttings from the first and second workpieces are brought into interlocking relationship within the adhesive layer.

11. A method according to Claim 3, wherein the at least temporarily fluent material is a fusible solid, and the workpiece is heated above a fusion temperature of the fusible solid as the latter is pressed against the workpiece so that the cuttings locally fuse and penetrate the solid.

12. A method of bonding surfaces of two workpieces of freely machinable material, comprising modifying the surfaces to be bonded by the method of Claim 2, and pressing the workpieces together such that the cuttings on the modified surfaces interlock.

13. A method according to Claim 1, wherein the workpiece is heated to render its material freely machinable.

14. A method of bonding surfaces of two workpieces, one of freely machinable material and the other of fibrous material, comprising modifying the surface of the one workpiece in accordance with Claim 1, interengaging fibres of the fibrous material of the other workpiece with the cuttings of the first workpiece, and compressing the cuttings against the first workpiece to trap the fibres.

15. A workpiece of freely machinable material having a generally planar surface with a plurality non-overlapping elongated channels cut in its surface with a non-detached curved, elongated, and at least partly retroverted cutting of said freely machineable material rooted at one end of each channel and springing from it initially in line with the channel and with said surface, the channels and cuttings being short compared with the dimensions of an area of the surface over which the channels are distributed.

16. A workpiece according to Claim 14, wherein the cuttings are retroverted through more than 180° relative to their roots.

17. A workpiece according to Claim 14, wherein said surface is treated to provide it with surface catalytic properties.

18. Apparatus for modifying a generally planar surface of a workpiece of freely machinable material, comprising at least one chisel member presenting a cutting edge at a planing angle to said surface, structure providing a gauging surface set back from said cutting edge and controlling depth of penetration of the cutting edge into the workpiece during planing movement of the cutting edge of each chisel member relative to the workpiece, structure providing a guide surface directing a cutting planed from the surface of the workpiece into a retroverting curve, and

mechanism operable to repeatedly relatively displace each chisel member and the workpiece through a predetermined planing stroke whereby to plane a non-detached cutting of predetermined length from a trough in a first zone of the surface, and operable to withdraw the chisel member from planing engagement with the workpiece, and means for permitting movement of the workpiece relative to the chisel member so that a following planing stroke may be performed on a further zone of the surface spaced from the first zone.

19. Apparatus according to Claim 18, including at least one tool carrying multiple chisel members presenting cutting edges at a planing angle to multiple locations on said surface.

20. Apparatus according to Claim 19, including at least two tools presenting multiple chisel members directed in opposite directions.

21. Apparatus according to Claim 20, including means to simultaneously displace said tools or sets of tools into planing engagement with the workpiece in the direction in which their chisel members are directed.

22. Apparatus according to Claim 18, comprising means to advance a workpiece presenting a generally planar surface along a defined path, mechanism withdrawing plural chisel members successively through a curved path tangential to said generally planar surface at a velocity less than the velocity at which the workpiece advancing means advances the workpiece, such that the chisel members successively penetrate the workpiece, execute a planing motion relative to the workpiece, and withdraw from the workpiece.

23. Apparatus according to Claim 18, including multiple chisel members each carried on a rotatable disk mounted for

reciprocating movement through an angle sufficient to move the chisel member into engagement with the workpiece and through a planing stroke, and to disengage the chisel member from the workpiece, and a coupling rod for conjointly reciprocating the disks carrying the chisel members.

Ridout & Maybee
101 Richmond St. West
Toronto, Canada M5H 2J7
Patent Agents of the Applicant

2127339

Fig. 1

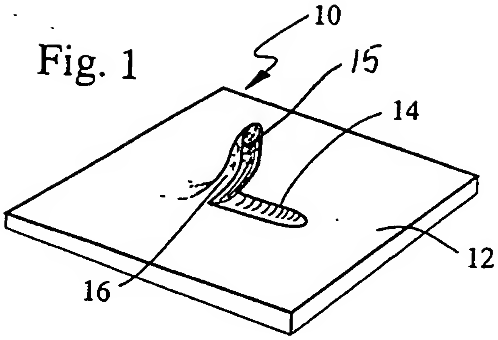


Fig. 2

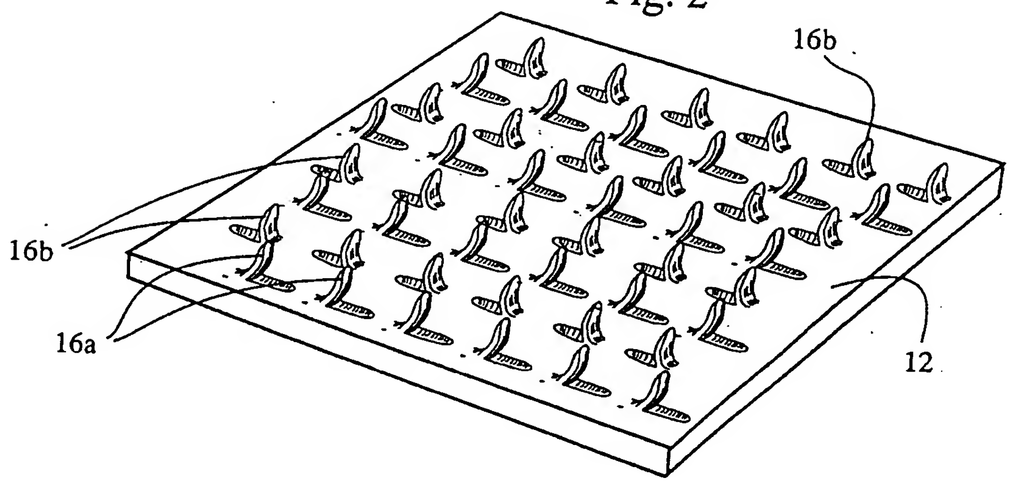


Fig. 3

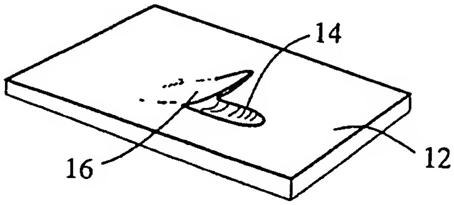


Fig. 4

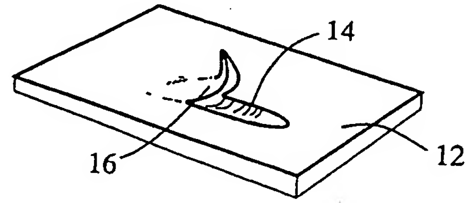


Fig. 5

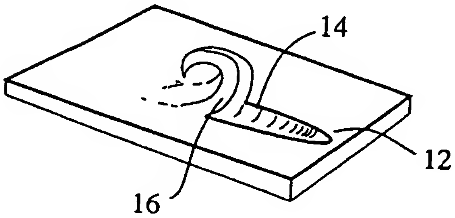
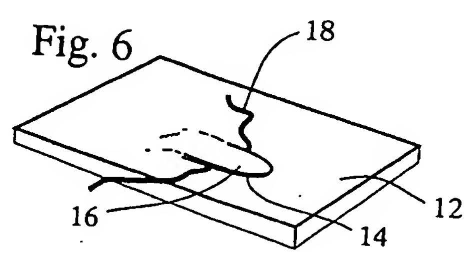


Fig. 6



Ridout & Maybee
PATENT AGENTS

Fig. 7

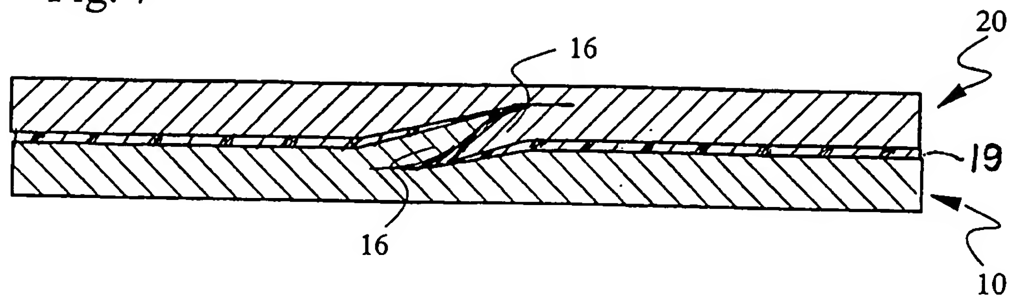


Fig. 8

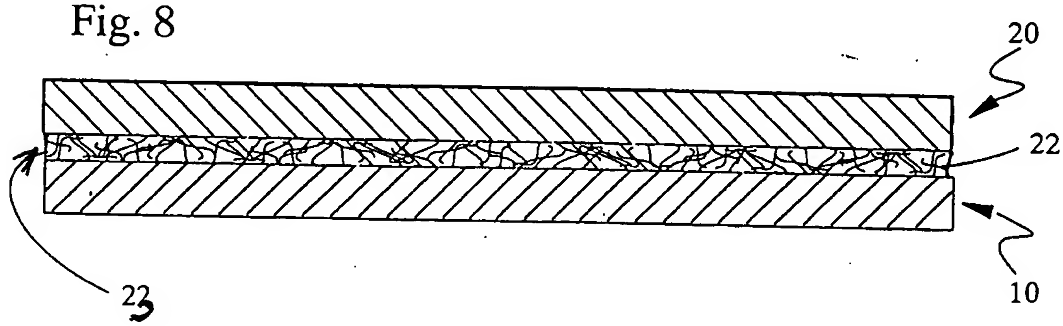


Fig. 9

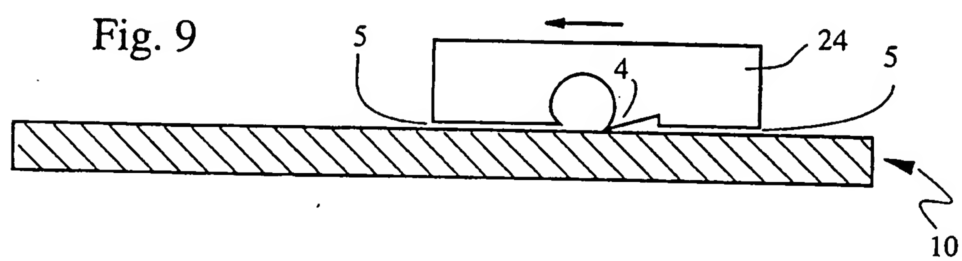
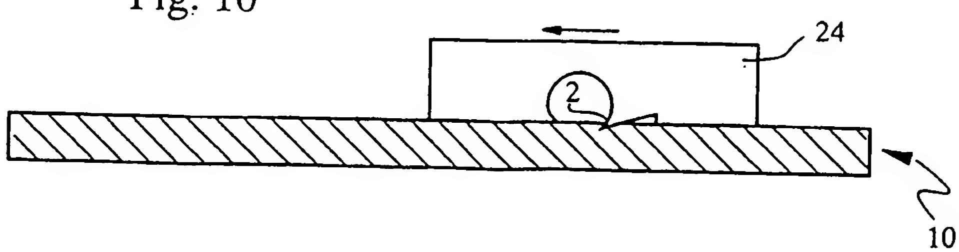


Fig. 10



Ridout & Maybee
PATENT AGENTS

2127339

Fig 11

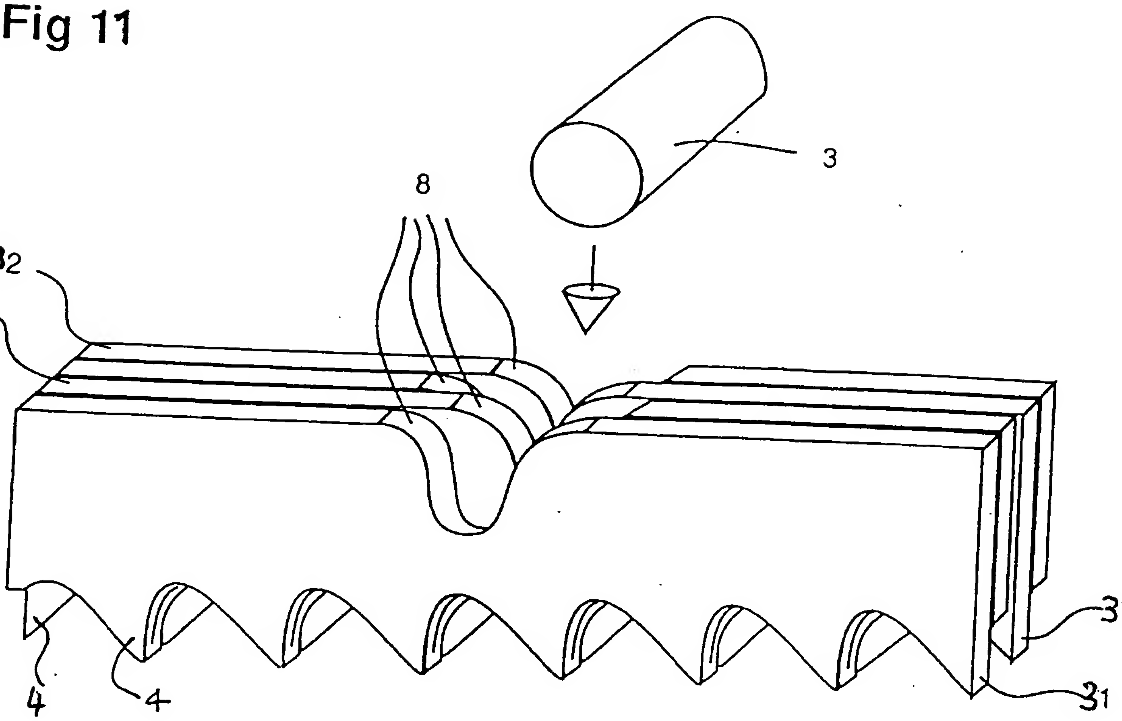
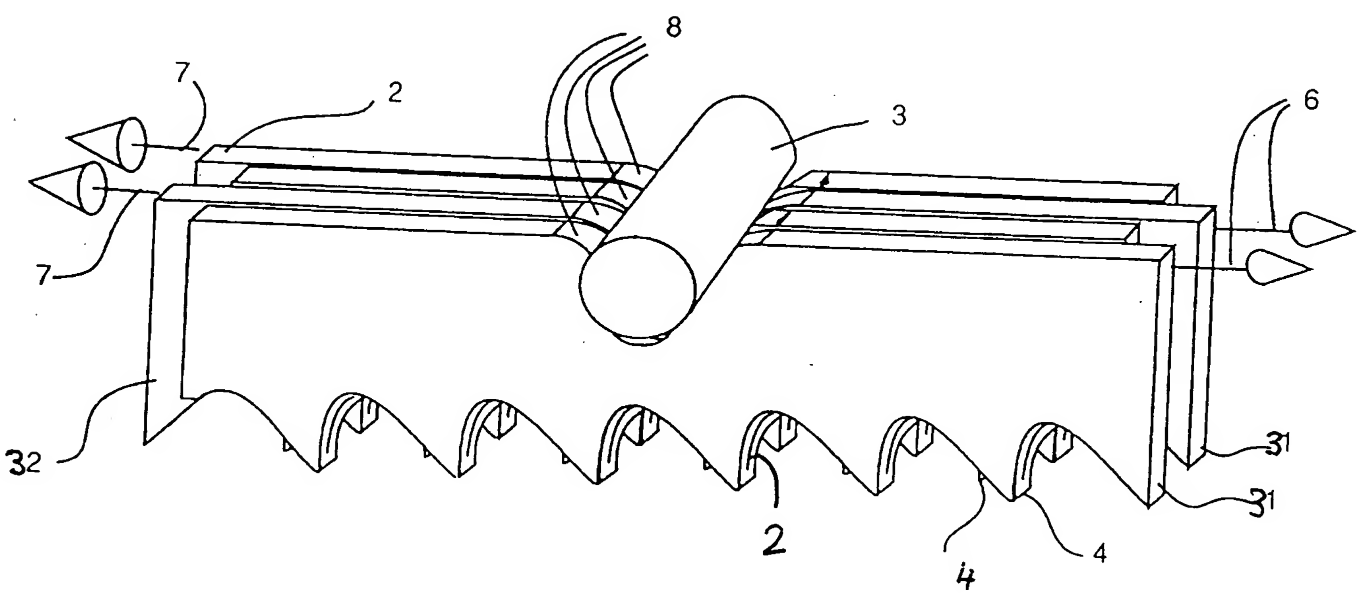


Fig12



Ridout & Maybee
PATENT AGENTS

FIG13

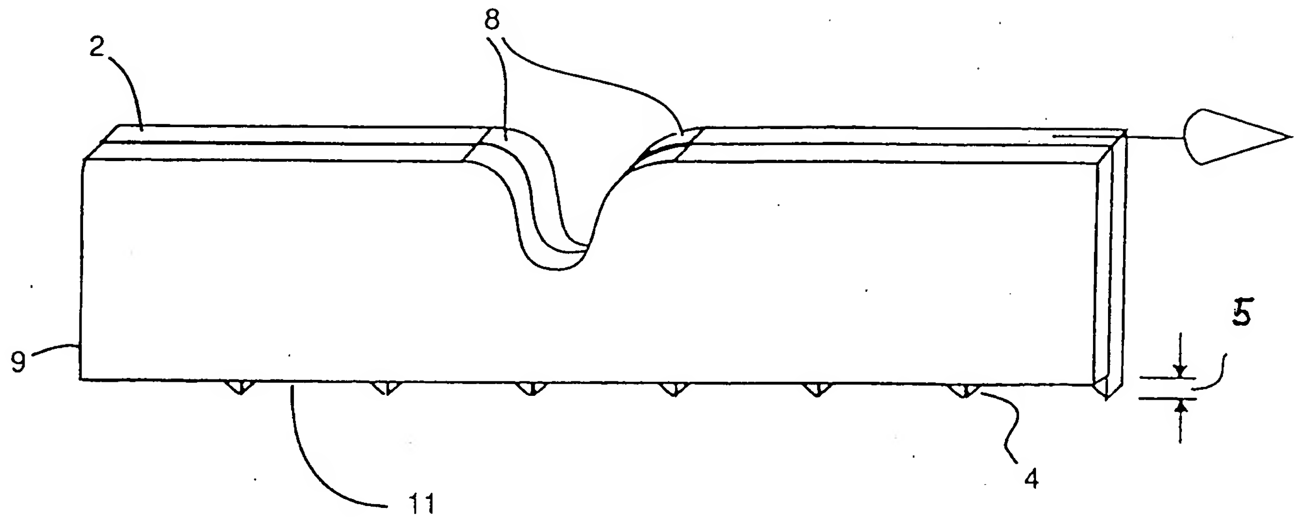
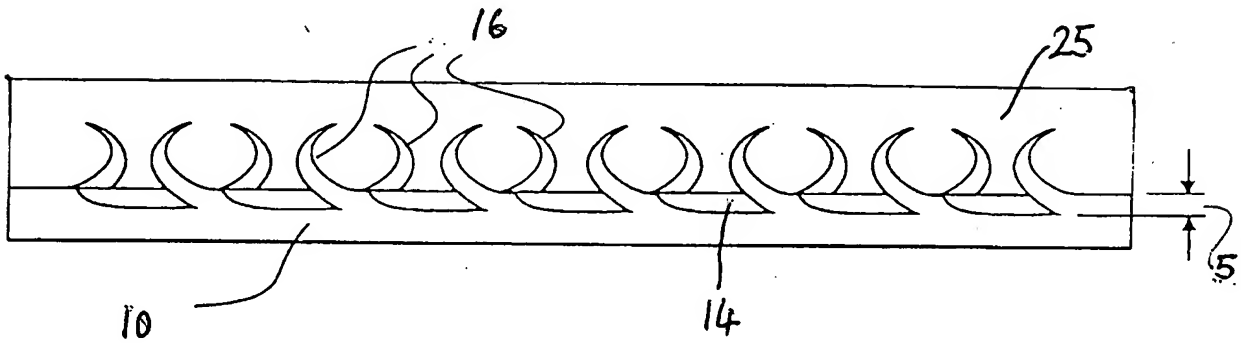


FIG14



Ridout & Maybee
PATENT AGENTS

2127339

FIG15

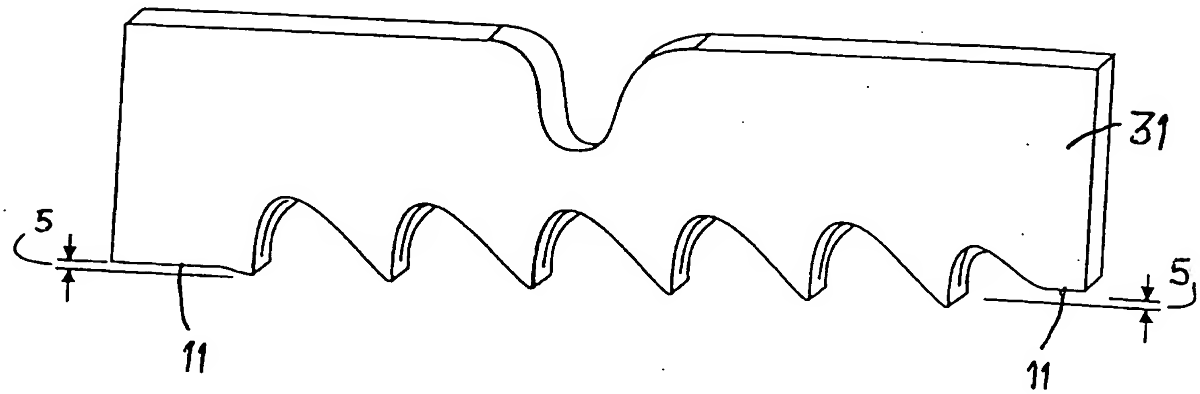


FIG16

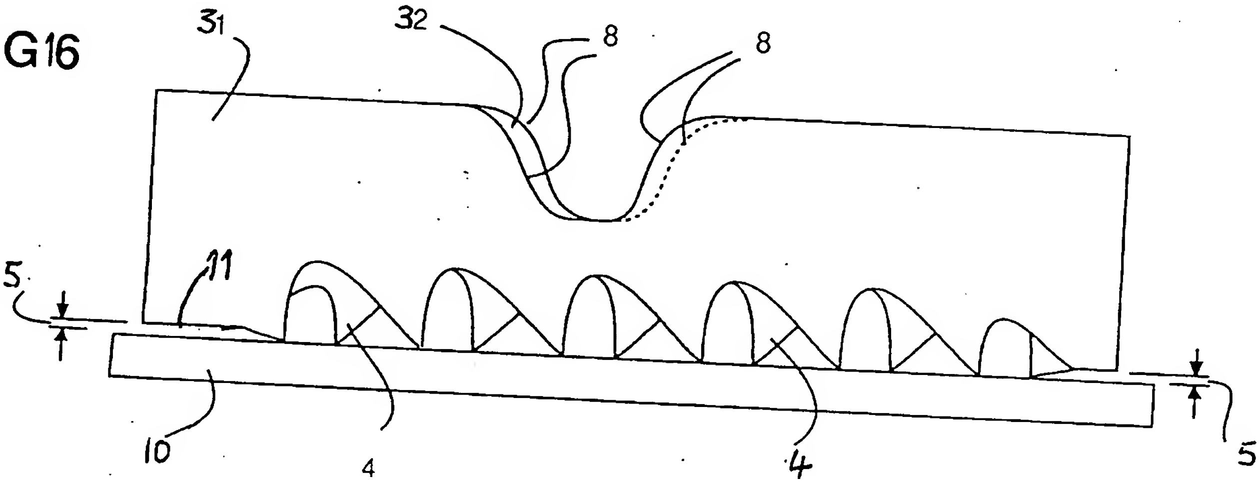
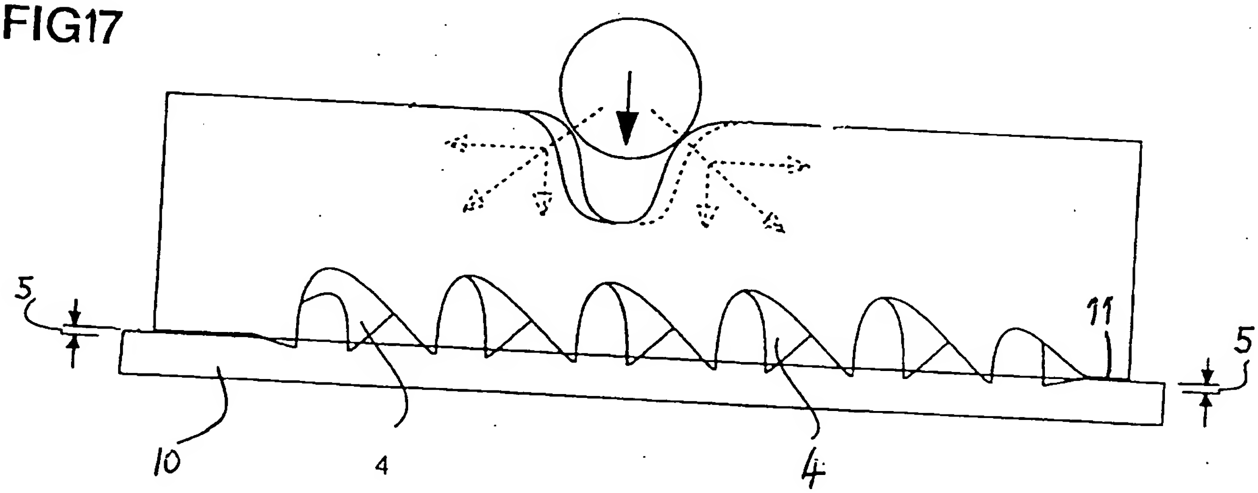


FIG17



Ridout & ...
PATENT AGENTS

2127339

Fig18

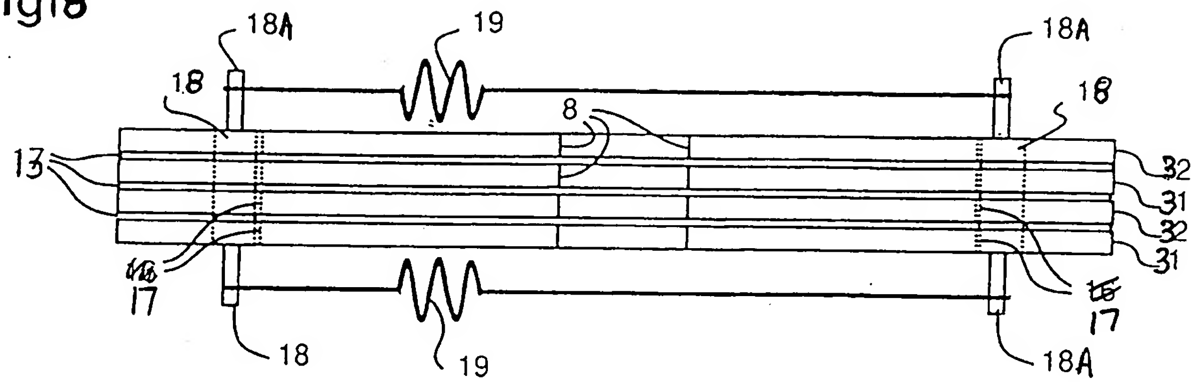


Fig 19

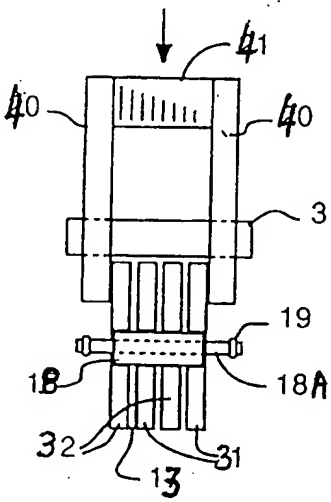


Fig 20

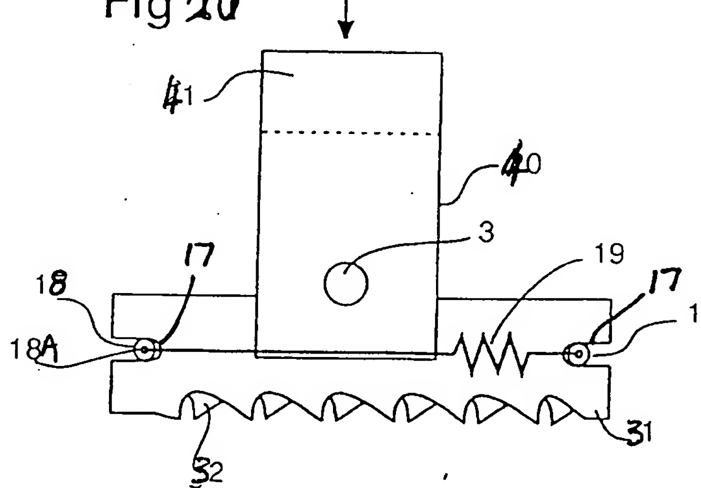
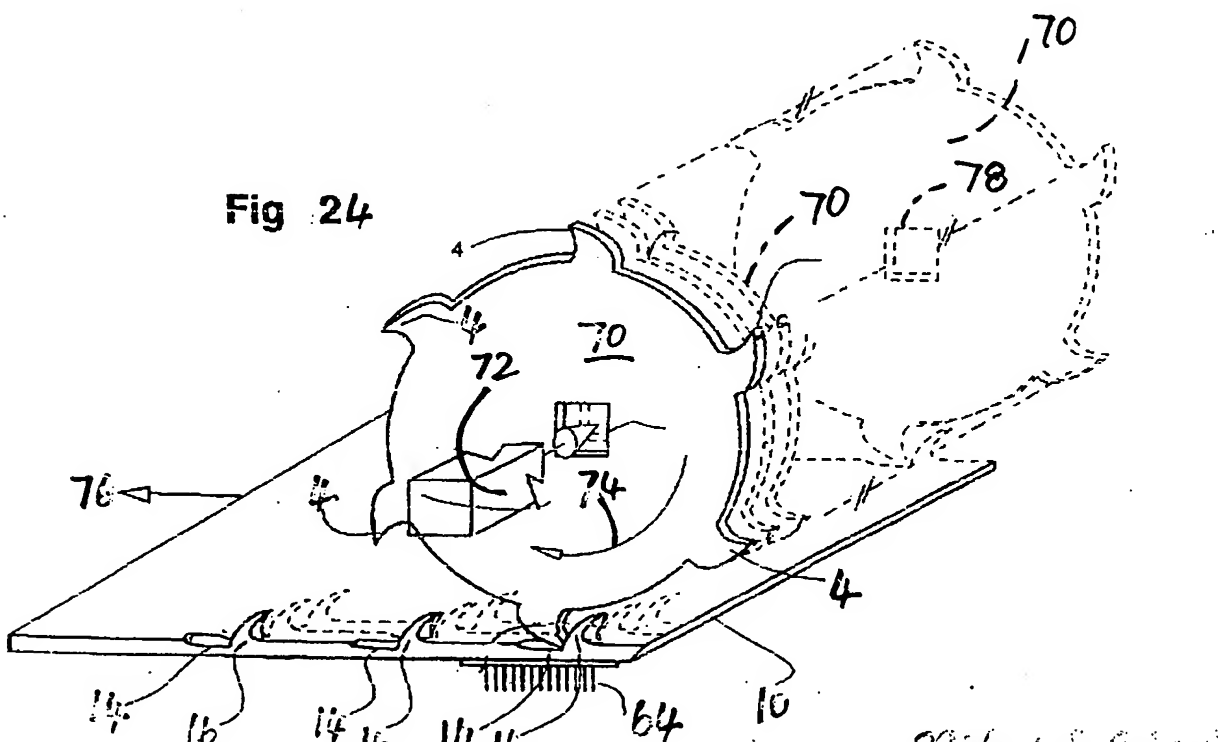


Fig 24



Ridout & Maybee
PATENT AGENTS

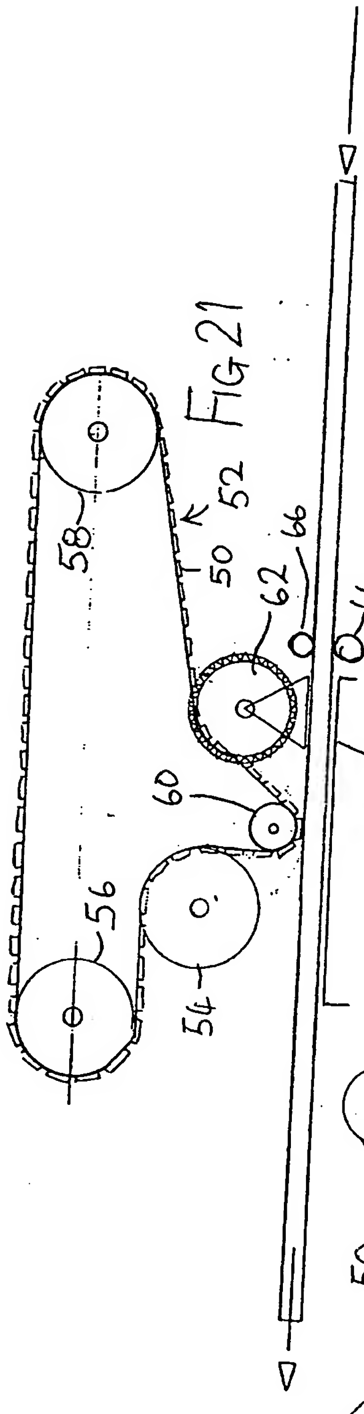


FIG 21

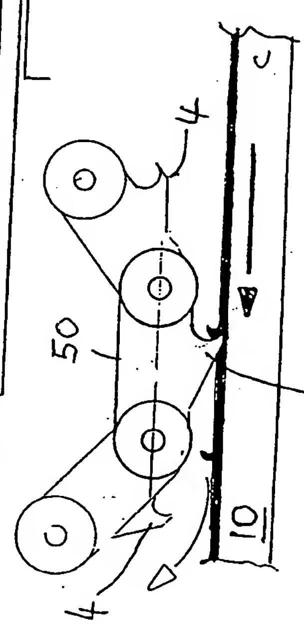


FIG 22

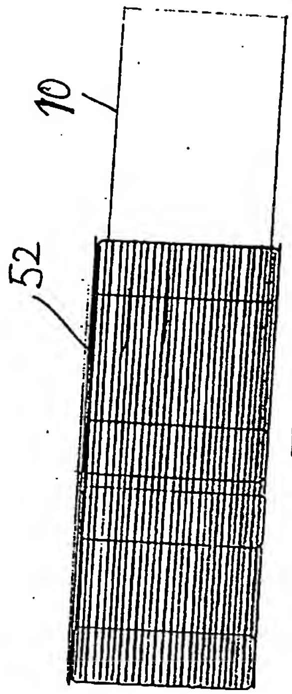


FIG 23

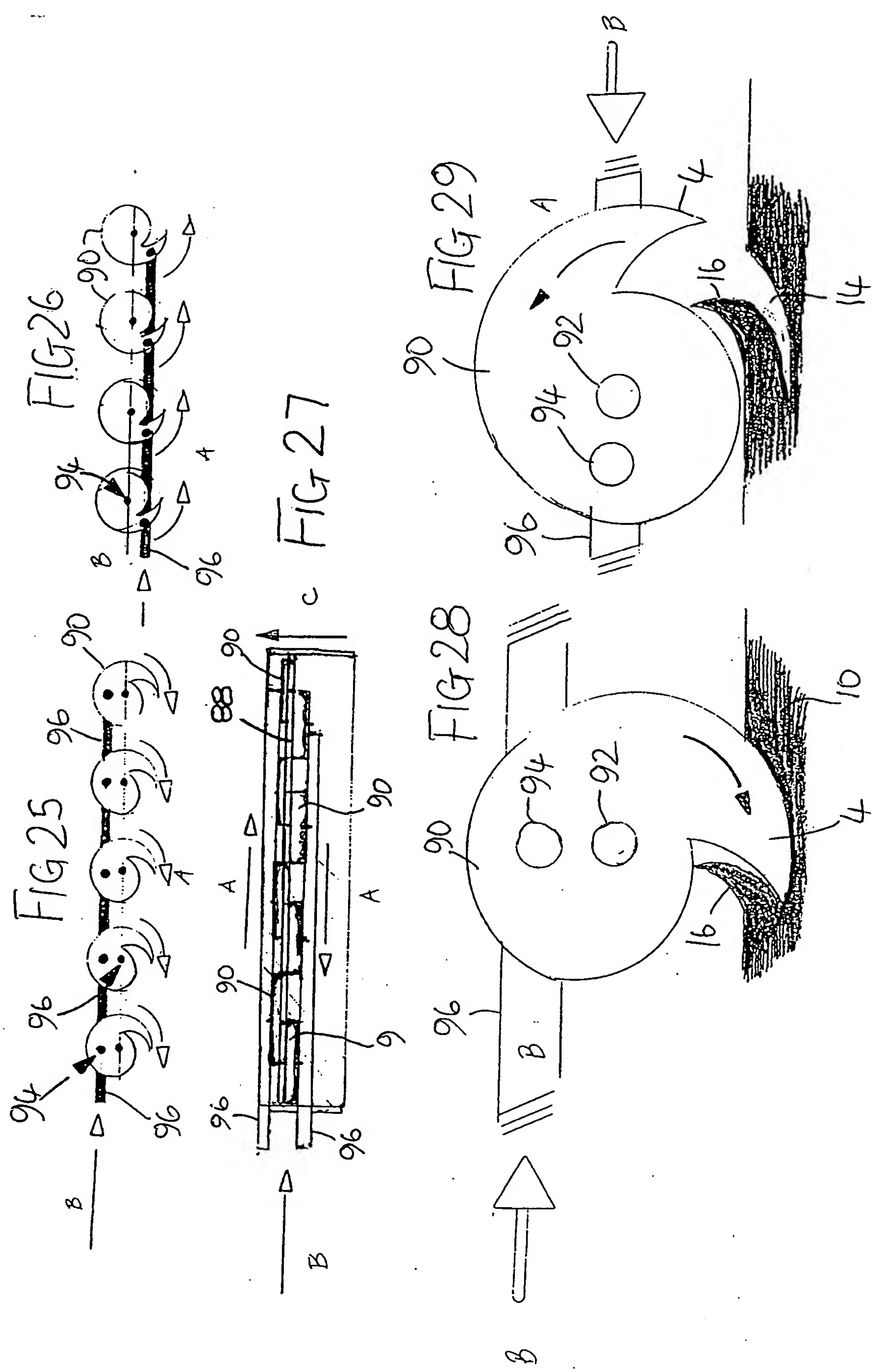


FIG 25

FIG 26

FIG 27

FIG 28

FIG 29

Ridout & Maybee
PATENT AGENTS